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# Deficit in decision making in catatonic schizophrenia: An exploratory study

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**Abstract**

Catatonic schizophrenia can be distinguished from paranoid schizophrenia by prominent behavioral and motor anomalies. As demonstrated in recent imaging studies, behavioral symptoms may be related to dysfunction in the ventral prefrontal cortex. However, the neuropsychological correlates of ventral prefrontal cortical dysfunction remain unclear. In an exploratory study, we investigated eight patients with catatonic schizophrenia and compared them with 19 patients with paranoid schizophrenia and 26 healthy subjects. The Iowa Gambling Task (IGT) and the Object Alternation Task (OAT) served as measures of ventral prefrontal cortical function. In addition, other prefrontal cortical tests such as a visual working memory task, a Go-NoGo task, and the Wisconsin Card Sorting Test, as well as attentional tasks, were included in the test battery. Catatonic patients showed significant deficits in the IGT characterized by an inability to shift from the initial preference for high-risk cards to a more advantageous strategy with low-risk cards. Moreover, catatonic patients showed significant deficits in the OAT. In conclusion, our preliminary results suggest a specific deficit in catatonic schizophrenia in those neuropsychological measures that are associated with ventral prefrontal cortical function.


*Keywords:* Catatonia; Behavioral anomalies; Iowa gambling task; Ventral prefrontal cortex; Dorsolateral prefrontal cortex

## 1. Introduction

Catatonia is a psychomotor syndrome that can be characterized by concurrent emotional (anxieties, depression, and mania), behavioral (mutism, stupor, stereotypies, and perseveration) and motor (akinesia, posturing, and catalepsy) alterations (Kahlbaum, 1878; Fink et al., 1993; Gelenberg, 1976; Northoff, 1997,

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2002; Taylor, 1990). Catatonia occurs in a variety of different diseases, but predominantly in schizophrenic or affective psychosis (Northoff, 1997, 2002; Taylor, 1990). In addition to motor anomalies, behavioral symptoms like automatic obedience, negativism, and echolalia/praxia are the most bizarre characteristics. These behavioral anomalies may be related to ventral prefrontal cortical dysfunction. This possible relationship is supported by evidence from both lesion and imaging studies. Studies in patients with lesions in the ventral prefrontal cortex show more or less similar behavioral anomalies (Bechara et al., 1999; Dias et al., 1996, 1997; Rolls, 1998). Imaging studies in catatonia reveal dysfunction in the ventromedial prefrontal cortex (Northoff, 2002; Northoff et al., 2004). However, the neuropsychological correlates of ventral prefrontal cortical dysfunction in catatonia remain unclear. One neuropsychological task, the Iowa Gambling Task, has been shown to be related to ventral prefrontal cortical function (see Bechara et al., 1994, 1999). We therefore administered the Iowa Gambling Task in an exploratory neuropsychological study of patients with catatonic schizophrenia.

Behavioral anomalies are the features that best distinguish catatonic schizophrenia from paranoid schizophrenia. Since both groups of patients suffer from the same underlying disease, i.e., schizophrenia, the behavioral anomalies found in catatonic patients may be specifically related to the catatonic subtype of schizophrenia. Accordingly, the behavioral anomalies may be characterized as subtype- rather than disease-related. Or one may conceive of the behavioral anomalies as being not only subtype-related but syndrome-related because catatonia is often associated with affective psychosis and other diseases (Taylor, 1990; Northoff, 1997, 2002).

In the present study, we tested only the first hypothesis, the occurrence of ventral prefrontal cortical neuropsychological anomalies specifically in catatonic schizophrenia as distinguished from paranoid schizophrenia: Is ventral prefrontal cortical neuropsychological dysfunction subtype-related in schizophrenia? Earlier investigations (Abbruzzese et al., 1997; Wilder et al., 1998; Cavallaro et al., 2003) demonstrated no deficit in the gambling task or other ventral prefrontal measures in patients with paranoid schizophrenia. In contrast, these patients showed severe deficits in tests examining the function of the dorsolateral prefrontal cortex (DLPFC) such as the Wisconsin Card Sorting Test and other tests of executive function. In addition to the gambling task, we therefore included the Wisconsin Card Sorting Test and executive tasks in our test battery.

Because our study includes only the catatonic and paranoid subtypes of schizophrenia, its exploratory findings cannot be generalized to other subtypes of schizophrenia (e.g., residual and disorganized subtypes). Moreover, due to the rare occurrence of catatonia in general and catatonic schizophrenia in particular, the number of investigated patients is necessarily low ($n=8$).

## 2. Methods

### 2.1. Subjects

Three groups of subjects were investigated: catatonic schizophrenic patients, paranoid schizophrenic patients and healthy subjects (see Table 1).

#### 2.1.1. Catatonic patients

We studied eight catatonic patients (5 women, 3 men; mean age=36.75 years, SD=10.48). They were selected from all incoming patients to a psychiatric university clinic in Magdeburg and psychiatric clinics in Haldensleben and Blankenburg between June 1999 and June 2000 (incidence, calculated in relation to all incoming patients: 2.9%). On admission, five patients were neuroleptic-naïve, two had been drug-free for the last 6 months after previous treatment with haloperidol/benperidol (dose range: 5–20 mg), and one was being treated with clozapine ($4\times100$ mg). No significant differences in psychopathological and neuropsychological measures were found between the neuroleptic-naïve and neuroleptic-exposed subgroups. By design, none of the patients had taken any benzodiazepines in the last 6 months before admission (as determined by serum concentration of benzodiazepines on day 0 according to the method by Greenblatt et al., 1978). Patients with chronic neurological and/or other physical illness, alcohol and/or substance abuse, hyperkinesias and/or dyskinesias as assessed by the Abnormal Involuntary Movements Scale (AIMS score>2; Guy, 1976), and/or neuroleptic-induced hypokinesias as assessed

Table 1
Clinical and demographic data (means ± SD) in catatonic and paranoid schizophrenic patients

| | Catatonic schizophrenia ($n=8$) | | Paranoid schizophrenia ($n=19$) | |
|---|---|---|---|---|
| | Means | SD | Means | SD |
| Age (years) | 36.75 | 10.48 | 38.50 | 13.99 |
| Years of education | 9.2 | 1.1 | 9.8 | 1.4 |
| No. of hospitalisations | 4.2 | 2.0 | 4.5 | 2.6 |
| Duration of illness (years) | 7.5 | 4.7 | 6.9 | 3.5 |
| Age at onset (years) | 28.5 | 8.3 | 29.8 | 8.9 |
| Time since actual onset (weeks) | 4.5 | 1.8 | 5.8 | 2.1 |
| Duration of treatment (years) | 5.9 | 4.2 | 6.0 | 4.1 |
| Neuroleptics (CPZ-equivalent) (mg) | 148.4 | 112.8 | 136.9 | 120.3 |
| Anticholinergics (no. of treated patients) | 4 | | 10 | |
| Global Assessment Scale (GAS) (day 0) | 14.9 | 3.6 | 20.5 | 3.9 |
| Positive and Negative Syndrome Scale (PANSS) (day 0) | 87.5 | 27.5 | 76.8 | 20.4 |
| No. of catatonic episodes | 4.6 | 1.9 | – | – |
| Days of catatonic symptoms | 14.8 | 6.3 | – | – |
| Rosebush Scale (average no. of symptoms) (day 0/1) | 9.9/1.5 | 1.9/0.8 | – | – |
| Bush–Francis Catatonia Rating Scale (day 0/1) | 27.5/3.1 | 7.5/1.2 | – | – |
| Northoff Catatonia Scale motor/affective/behavioral/total (day 0) | 21.4/22.8/20.7/64.9 | 3.9/4.6/4.3/11.2 | – | – |

by the Simpson–Angus Scale of Extrapyramidal Side Effects (SEPS score>3; Simpson and Angus, 1970) were excluded from the study.

Co-morbid diagnoses were assessed in accordance with DSM-IV criteria (American Psychiatric Association, 1994) at the time of discharge by two independent psychiatrists using a structured clinical interview. All patients were diagnosed as catatonic schizophrenia (295.20). The Edinburgh Inventory of Handedness (Oldfield, 1971) established that all patients were right-handed. General psychopathological assessments included the Global Assessment Scale (GAS; Endicott et al., 1976) and the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987).

Catatonic syndrome was diagnosed according to the criteria of Lohr and Wisniewski 1987 (3 out of 11 symptoms), Rosebush et al. (1990) (4 out of 12 symptoms), the Bush–Francis Catatonia Rating Scale (BFCRS; Bush et al., 1996), and the Northoff Catatonia Scale (NCS; Northoff et al., 1999a,b) with its different subscales (motor, affective, and behavioral). These scales use a rather strict definition of catatonia by relying on a cluster of symptoms, as recommended by Gelenberg (1977). Catatonic symptoms had to be manifested on the day of admission in the presence of both examiners (G.N., S.D.). Furthermore, patients had to show complete akinesia (i.e., no voluntary movements at all) for at least half an hour in the presence of the examiners. All patients had to be classified as akinetic catatonic (hyperkinetic catatonic patients were excluded because hypokinetic and hyperkinetic catatonia may differ in their pathophysiological mechanisms (Northoff et al., 1995) according to all three criteria lists (i.e. all patients qualified as catatonic on all criteria sets) with agreement on every symptom by two independent psychiatrists (G.N., S.D.) who rated the same patients successively within 1 h on day 0.

On admission, all catatonic patients received only lorazepam 2–4 × 1–2.5 mg (mean = 4.9 mg, SD = 1.5) intravenously in the first 24 h. On the basis of the clinical response to lorazepam in the first 24 h, judged by the criteria of Lohr and Rosebush, we distinguished between short-term responders ($n=8$) and non-responders ($n=2$) from which only the former but not the latter were included in the study, because catatonic responders and non-responders to lorazepam might show different underlying pathophysiological mechanisms (Northoff et al., 1995, 1998). After full resolution of the catatonic syndrome on day 1, lorazepam was

discontinued and patients received typical neuroleptics ($n=8$) without any further use of benzodiazepines, anticholinergics or other medication. Neuropsychological investigations took place in the fourth week after admission.

#### 2.1.2. Paranoid schizophrenic patients and healthy subjects

We investigated two control groups, paranoid schizophrenic patients and healthy controls. The paranoid schizophrenic group (7 women, 13 men; mean age=38.50, SD=13.99 years; all right-handed) included 19 recently admitted patients. Diagnoses of DSM-IV paranoid schizophrenia (295.30) were determined in a semistructured interview carried out by an independent psychiatrist. Psychopathological assessments in the paranoid subgroup were similar to those in the catatonic patients (see above). Schizophrenic patients with hypokinetic (SEPS score>3) or hyperkinetic (>3) neuroleptic-induced side effects, previous catatonic symptoms/episodes, alcohol/substance abuse, benzodiazepine medication in the last 6 months, and/or neurological or physical illness were excluded from the study. Moreover, schizophrenic patients received the same treatment (initially benzodiazepines, then typical neuroleptics without any further medication) and underwent neuropsychological testing at the same 4-week time point as the catatonic patients.

In addition to the catatonic and paranoid schizophrenic patients, 26 healthy controls (14 women, 12 men; mean age=29.81 years, SD=9.39) were studied; for details concerning exclusion criteria, see Northoff et al. (1999a,b).

#### 2.1.3. General psychopathological assessment

On the day of admission, general clinical state was assessed with the Global Assessment Scale (GAS; Endicott et al., 1976). Positive and negative schizophrenic symptoms were defined using the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987).

### 2.2. Neuropsychological assessment

Standardized, commonly used tests were selected to generate a battery that would assess those neuropsychological abilities presumed to be related to the function of the ventral prefrontal cortex. The single testing session never exceeded 80 min and was administered in a quiet laboratory in a standardized sequence.

#### 2.2.1. Gambling Task

The Iowa Gambling Task (Bechara et al., 1994) requires a long series of card selections with 100 selections from four decks of cards that are identical in appearance. The subjects are told that the goal of the task is to maximize profit and are given a $2000 loan of play money. After turning over some cards, the subjects are given money and sometimes asked to pay a penalty according to a programmed schedule of reward and punishment. Gain and loss are different for each card selected from the four decks. Deck A and deck B are "disadvantageous." Although these decks pay around $100, their penalty amounts are higher, so that they cost more in the long run, resulting in an overall loss. In deck A, punishment is more frequent but of smaller magnitude than in deck B. Decks C and D, in contrast, are "advantageous." Although these decks pay only around $50, their penalty amounts are lower, so that they result in an overall gain in the long run. In deck C, punishment is more frequent but of smaller magnitude than in deck D. In short, decks A and B can be regarded as "high-risk" decks, whereas decks C and D can be considered as "low-risk" decks. By choosing only from the "low-risk" decks C and D, a subject can make an overall gain above the original loan of $2000. In contrast, there is an overall loss associated with choosing primarily from the "high-risk" decks A and B.

First, the differences between the total number of "disadvantageous" (A and B) and "advantageous" (C and D) cards selected were compared. Second, the total of 100 cards selected was subdivided into four blocks of 25 cards each. For each block, the number of cards selected from the "disadvantageous" (A and B) and "advantageous" (C and D) decks was counted and compared (Bechara et al., 1999). In that way, a distinction between random or deliberate decision-making performance could be made. Third, the difference between the different blocks (first, second, third and fourth blocks) of the different decks was compared within as well as between groups. The third step assessed the strategy of performance, e.g., the

increased selection over time of cards from "low-risk" decks.

*2.2.2. Object Alternation Task (OAT) and Go-NoGo task*

In the OAT, the subject sees two gray fields on a screen (for description, see Freedman, 1990). Behind one of the fields, a reward (a face with a smile) is hidden. Subjects choose from both fields and must develop a strategy to detect the rule by which the rewards are distributed. The ability to shift sets and to use working memory is measured in the task.

In the Go-NoGo task (Zimmermann and Fimm, 1994), subjects hear a high or low tone. They have to press a button only when a high tone is heard. No button has to be pressed after the low tone. The ability to suppress responses is measured.

*2.2.3. Working memory*

In a test of verbal working memory through the presentation of numbers (Zimmermann and Fimm, 1994), subjects have to decide whether the present word/number is identical to the second—last one. Missing items, mistakes and reaction times are recorded.

In a visuo-spatial working memory task, two spatial figures at different positions are presented for 3 s on the screen. After a brief break (3–5 s), one of the two figures reappears on the screen. Subjects have to decide whether this figure appears either in the same or a different position compared with its first presentation. Reaction times and mistakes are recorded.

*2.2.4. Wisconsin Card Sorting Test (WCST)*

The WCST (Bergh, 1948) assesses abstraction ability and the ability to shift cognitive strategies in response to changing environmental contingencies. It assesses the kind of executive functioning involved in strategic planning and organized searching, as well as the ability to use environmental feedback to shift cognitive sets. Four stimulus cards with symbols differing in color, shape and number are placed in front of the subject, who is given a pack of 64 response cards. Each card varies in its combination of color, shape and number. The subject is asked to match each response card to one of the stimulus cards, the aim being to get as many correct matches as possible. The subject does not know the criterion for the respective match between the two kinds of cards. After each trial, the subject is told whether the match is correct or incorrect. After 10 consecutive correct matches, the criterion is switched until all cards have been placed. After all the cards in the first deck have been picked, a second deck of 64 cards pre-sorted in the same order is used. The indices considered to evaluate the test are the following: number of stages completed by the subjects (WCST-SN) and perseverative error score (WCST-PE). There is no time limit to complete the task. The WCST has been shown to be particularly sensitive to lesions in the dorsolateral prefrontal cortex (Abbruzzese et al., 1997; Freedman et al., 1998).

*2.2.5. Attention*

The task for incompatibility (Zimmermann and Fimm, 1994) assesses the sensitivity to interference due to an incompatibility between the stimulus and the response. Arrows are presented on the right or on the left of a fixation point. The arrows point to the right or to the left. Participants have to react to the arrow's direction. The right hand is used when the arrow is pointing to the right, while the left hand is used when the arrow is pointing to the left, whatever the arrow position on the screen (left vs. right). There is compatibility when the arrow is displayed on the side corresponding to the answering hand. On the contrary, there is incompatibility when the hand and the arrow are on opposite sides. Sixty stimuli are presented (15 stimuli compatible and incompatible in each visual hemifield).

In the divided attention task (Zimmermann and Fimm, 1994), either visual figures or auditory signals have to be recognized. Their presentation is accompanied by other figures or signals that need to be distinguished from the ones to be recognized.

*2.2.6. General intellectual functioning*

The Standard Progressive Matrices (SPM; Raven, 1976) consists of 30 items of a collection of figures, with one missing figure, respectively. The missing figure has to be completed according to the logically correct solution by selection from various alternatives. The number of correctly completed figures reflects the age-specific non-verbal IQ.

The Multiple Vocabulary Test-B (MWT-B; Lehrl, 1995) consists of 37 items, each showing different words from which only one is meaningful (i.e. the other words are nonsense). The one meaningful word has to be recognized, and the number of correctly recognized words serves as the basis for calculation of the age-specific verbal IQ. The MWT-B shows a high correlation with other more sophisticated measures of intelligence such as, for example, the Wechsler Adult Intelligence Scale, which were not administered here because of time constraints.

### 2.3. Statistical analysis

Demographic data and psychopathological scores were compared in the two patient groups by two-tailed independent *t*-tests. Neuropsychological test differences among the three groups were tested using analysis of variance (ANOVA) with repeated measures and post-hoc *t*-tests with correction for multiple comparisons.

## 3. Results

### 3.1. Clinical and demographic data

Demographic data and non-catatonic psychopathological scores showed no significant differences between catatonic and paranoid schizophrenic patients.

### 3.2. Neuropsychological measures

#### 3.2.1. General intellectual function

No significant differences in (mean ± SD) verbal (MWT-B: catatonic: 31.4 ± 2.4; paranoid: 30.6 ± 2.7; healthy: 32.1 ± 1.9) and non-verbal (SPM: catatonic: 27.5 ± 1.9; paranoid: 26.7 ± 2.1; healthy: 27.8 ± 2.0) intelligence scores were found.

#### 3.2.2. Gambling task

Healthy and paranoid schizophrenic subjects showed significant differences between early and late cards in the within-group analysis (see Fig. 1). Both

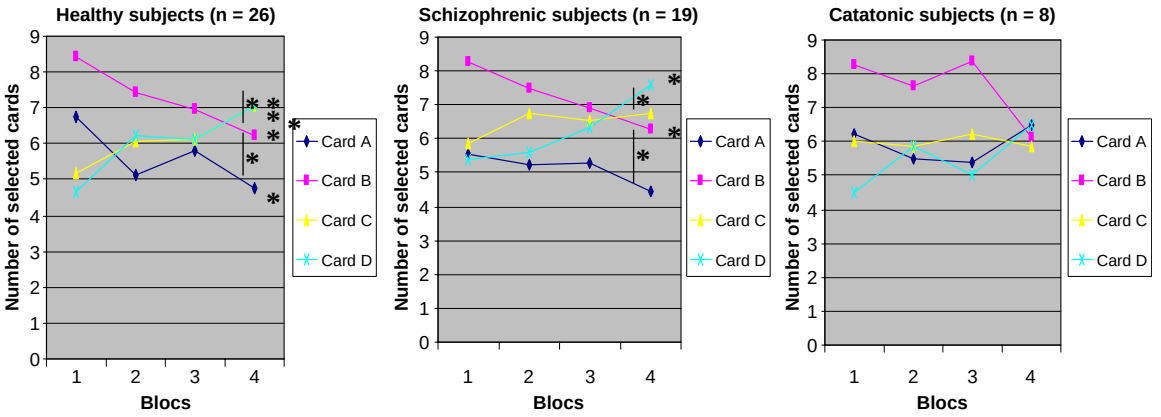


Fig. 1. Selection of high- and low-risk cards over time in healthy, paranoid schizophrenic, and catatonic schizophrenic subjects. Cards A and B: High-risk cards, Cards C and D: Low-risk cards. Blocks 1–4: Time course of blocks. Means for each type of card in each block are presented for each group separately. Note the differences in the overall pattern with regard to the time course between catatonic schizophrenic patients on the one hand and paranoid schizophrenic and healthy subjects on the other. The selected number of high-risk cards A and B is decreasing significantly, and the number of selected low-risk cards (C and D) is increasing significantly over time in both healthy and paranoid schizophrenic subjects ($P<0.05$, corrected). This is true for both single cards and high- and low-risk cards taken together. In contrast, this pattern is no longer present in catatonic schizophrenic patients. Instead of decreasing, card A increases in the last block. Card B decreases, though later than in the other groups. Card C does not increase, as in the other groups, but remains the same. Card D shows an increase in the last block which, however, is lower (and thus non-significant) than in the other groups. Catatonic schizophrenic patients therefore no longer show the opposite changes in the selection of high- and low-risk cards over time that can be observed in both healthy and paranoid schizophrenic subjects. Accordingly, no significant differences in the selection of cards can be observed over time in catatonic schizophrenic patients. *=$P<0.05$ (corrected); significant difference between first block (1) and last block (4) for a single card. |*=$P<0.05$ (corrected); significant difference between the first block (1) and the last block (4) for high-risk (A, B) and low-risk (C, D) taken together, respectively.

groups showed a significantly lower number of all (when taken together) high-risk cards (A and B) in the last block (block 4) than in the initial block (block 1). The number of all low-risk (when taken together) cards (C and D) increased significantly over time in both groups. This was also true for single cards in healthy subjects; all single cards (A, B, C and D) differed significantly between the initial block and the last block (see Fig. 1). In paranoid schizophrenic patients, only cards B and D differed significantly over time. However, the addition of high- and low-risk cards, respectively, revealed significant differences over time in paranoid schizophrenic patients (see above and Fig. 1).

In contrast to healthy controls and paranoid schizophrenic subjects, this pattern was not observed in catatonic patients. They showed neither a significant decrease in high-risk cards nor a significant increase in low-risk cards over time, i.e., the number of high- and low-risk cards did not change significantly over time in catatonic schizophrenic patients.

To confirm this finding, we compared the early and late time points with regard to the relation between high- versus low-risk cards ((AB1–CD1)–(AB4–CD4)) within each group. Both healthy ($df=25$, $P<0.001$, corrected) and paranoid schizophrenic ($df=18$, $P<0.004$, corrected) subjects showed a significant difference between the early and late difference of high-risk versus low-risk cards. In contrast, this was not the case in the catatonic patients, i.e., the healthy and paranoid schizophrenic subjects showed a significant change in the relation between high- versus low-risk cards over time that was absent in catatonic patients.

To exclude differences in early selection of high- and low-risk cards that could have accounted for the differences in relation over time, we compared the three different groups with regard to differences in the initial two (1/2) blocks (A1/2, B1/2, C1/2, D1/2; AB1/2, CD1/2). There were no significant differences among the three groups (Fig. 1).

In summary, catatonic patients showed a different and abnormal pattern in the selection of high- and low-risk cards over time relative to both healthy and paranoid schizophrenic subjects. In contrast to catatonic patients, no abnormalities in the patients with paranoid schizophrenia were observed.

### 3.2.3. Other tests

In almost all tests, catatonic and paranoid schizophrenic subjects showed significantly longer reaction times than healthy subjects. In contrast, there were no

Table 2
Comparison between catatonic schizophrenic, paranoid schizophrenic, and healthy subjects in neuropsychological prefrontal cortical measures

| | | Catatonic schizophrenia ($n=8$) | Paranoid schizophrenia ($n=19$) | Healthy ($n=26$) | ANOVA ($F$; $P$) |
|---|---|---|---|---|---|
| Object Alternation Task | RT | 3647.9 ± 2210.41** | 3215.30 ± 1325.12*** | 1847.5 ± 691.6**,*** | 10.1; 0.000 |
| | MT | 18.63 ± 9.07* | 11.25 ± 10.43*,*** | 4.19 ± 3.15**,**** | 12.7; 0.000 |
| Verbal working memory | RT | 830.0 ± 328.9** | 824.1 ± 175.17*** | 595.2 ± 123.02**,*** | 10.6; 0.000 |
| | MT | 6.13 ± 6.83** | 5.75 ± 6.04*** | 1.31 ± 1.93**,**** | 6.4; 0.003 |
| | MS | 5.13 ± 3.9** | 3.65 ± 2.46 | 1.85 ± 2.15** | 6.0; 0.005 |
| Go-NoGo Task | RT | 493.13 ± 128.64** | 498.74 ± 88.27*** | 386.96 ± 52.1**,*** | 12.0; 0.000 |
| | MT | 5.63 ± 5.66** | 4.00 ± 6.18 | 0.88 ± 1.36** | 4.7; 0.014 |
| Wisconsin Card Sorting Test | MT | 47.88 ± 17.20** | 43.25 ± 27.12*** | 27.31 ± 15.11**,*** | 4.9; 0.012 |
| | CC | 4.00 ± 1.77** | 4.00 ± 2.41*** | 5.35 ± 0.98**,*** | 4.0; 0.024 |
| Divided attention | RT | 798.25 ± 196.38** | 761.63 ± 82.31*** | 687.2 ± 63.78**,*** | 5.3; 0.008 |
| | MT | 1.13 ± 1.36 | 1.37 ± 2.36 | 0.65 ± 1.09 | 1.0; 0.371 |
| | MS | 3.50 ± 3.42 | 4.68 ± 3.73*** | 1.38 ± 1.79*** | 7.5; 0.001 |

RT = Reaction time; MT = Number of mistakes; MS = Number of missing items; CC = Number of categories completed.
*Significant difference ($P<0.05$, corrected) between catatonic and paranoid schizophrenics subjects; **Significant difference ($P<0.05$, corrected) between catatonic schizophrenic and healthy control subjects; ***Significant difference ($P<0.05$, corrected) between paranoid schizophrenic and healthy control subjects.
Note that catatonic and paranoid schizophrenic patients differ significantly from each other in the Object Alternation Test (OAT). In contrast, in the other tests there is no significant difference between the two groups. Reaction times are significantly higher in both psychiatric groups than in healthy subjects, whereas there is no significant difference between catatonic and paranoid schizophrenic subjects. Alterations in reaction times may be due to treatment with typical neuroleptics in both psychiatric groups.

significant differences between the two psychiatric groups (see Table 2). Prolonged reaction times could reflect the effects of treatment with typical neuroleptics in both schizophrenic groups.

*3.2.3.1. Object Alternation Test (OAT).* Catatonic patients made significantly more mistakes ($P<0.049$/0.000, corrected) than paranoid schizophrenic patients and healthy control subjects (see Table 2). The paranoid patients made significantly more mistakes than the healthy subjects ($P<0.008$, corrected).

*3.2.3.2. Working memory.* In the verbal working memory task, catatonic patients showed significantly ($P<0.008$, corrected) more missing items than healthy subjects. Both catatonic ($P<0.042$) and paranoid ($P<0.007$, corrected) schizophrenic patients made significantly more mistakes than healthy subjects (see Table 2).

*3.2.3.3. Go-NoGo test.* Catatonic patients made significantly more mistakes ($P<0.033$, corrected) than healthy subjects (see Table 2).

*3.2.3.4. Wisconsin Card Sorting Test.* Both the catatonic and paranoid schizophrenic patients completed significantly fewer categories than the healthy subjects ($P<0.037$/0.041, corrected) (see Table 2).

*3.2.3.5. Attentional tasks.* Patients with paranoid schizophrenia showed a significantly ($P<0.037$, corrected) higher number of missing items in the divided attention task than healthy controls.

## 4. Discussion

The main findings in the present neuropsychological study are the following: (i) specific abnormalities in the Iowa gambling task in catatonic schizophrenia; (ii) specific abnormalities in the Object Alternation Task (OAT) in catatonic schizophrenia.

### *4.1. Neuropsychological dysfunction in catatonic schizophrenia*

In contrast to healthy and paranoid schizophrenic subjects, catatonic patients did not show significant changes in the selection of high-risk (A, B) and low-risk (C, D) cards over time in the gambling task. Instead of decreasing, the number of A cards increased in the last block. The number of B cards decreased, though only in the last block. The number of C cards did not increase over time, whereas D cards showed only a rather moderate increase (see Fig. 1). Accordingly, catatonic schizophrenic patients did not show the opposite changes in the selection of high-risk (A, B) and low-risk (C, D) cards over time as was observed in both healthy and paranoid schizophrenic subjects. One may consequently assume a deficit in decision-making in catatonic schizophrenia with an inability to shift from initial, i.e., high-risk, preferences to a more advantageous, i.e., low-risk strategy. This deficit in decision-making seems to be specifically related to the subtype of schizophrenia, i.e., catatonic schizophrenia, since it was not observed in patients with paranoid schizophrenia.

This inability to shift initial preferences to a more advantageous strategy may be traced back to neuropsychological deficits in set shifting. Set shifting may be considered as an essential component predominantly involved in identifying and implementing an advantageous behavioral strategy (Freedman et al., 1998; Manes et al., 2002; Bechara et al., 2000). We tested the ability of the subjects in behavioral set shifting with the Object Alternation Test (OAT). Our results revealed that catatonic patients made significantly more mistakes than paranoid patients. Clinically, this deficit in behavioral set shifting may eventually be reflected in behavioral anomalies such as perseverations, stereotypies, echolalia/praxia, negativism, and automatic obedience where patients show an inability to shift to a different motor behavior.

### *4.2. Neuropsychological dysfunction in paranoid schizophrenia*

In contrast to catatonic patients, paranoid schizophrenic patients did not show any deficits in the Gambling Task and were able to shift their initial high-risk strategy to a more advantageous low-risk strategy. Similar findings were observed by Wilder et al. (1998) and Cavallaro et al. (2003), who also did not find any deficits in decision-making in paranoid schizophrenia.

How can we account for the present finding of a deficit in the Gambling Task in catatonic schizophrenia? Is it due to medication? Both groups received analogous medication, e.g., typical neuroleptics. A recent study in paranoid schizophrenia (Beninger et al., 2003) compared the influence of typical and atypical neuroleptics on the Gambling Task in schizophrenic patients. Patients treated with typical neuroleptics did not reveal any changes in the Gambling Task, whereas those treated with atypical neuroleptics showed major deficits. This is in accordance with the present results. Both paranoid and catatonic schizophrenic patients were treated with typical neuroleptics. Similar to the study by Beninger et al. (2003), paranoid schizophrenic patients did not show any deficits in the Gambling Task, whereas catatonic patients did show major deficits. Since they were not treated with atypical neuroleptics, this deficit cannot be due to medication.

This raises the question of the nosological significance of the present findings. Our finding of a ventral prefrontal cortical neuropsychological deficit in catatonic schizophrenia must be considered as specific for catatonic schizophrenia since it was not observed in paranoid schizophrenia. Accordingly, one may assume that the present finding is subtype-related rather than disease-related. However, since we did not investigate other subtypes of schizophrenia (e.g., residual, hebephrenic), the assumption of a subtype-related rather than a disease-related origin can at best be regarded as tentative. Moreover, the present study did not take into account the syndromal character of catatonia, i.e., that it also occurs in patients with affective psychosis and other diseases (Taylor, 1990; Northoff, 1997, 2002). Accordingly, no distinction between the (schizophrenic) subtype-related versus syndrome-related origin of the observed neuropsychological deficits in decision-making can be made.

### *4.3. Neuroanatomical dysfunction in catatonic and paranoid schizophrenia*

Neuroanatomically, the deficit in decision-making and behavioral set shifting in catatonic schizophrenia may be related to dysfunction in the ventral prefrontal cortex. Similar to catatonia, patients with lesions in ventral prefrontal cortex show an almost analogous pattern in the Gambling Task with an inability to shift to more advantageous strategies, i.e., they too suffer from an "insensitivity to future consequences" with a "myopia for the future" (Bechara et al., 1998, 2000). On the basis of these and the present findings, one may infer a possible alteration in ventral prefrontal cortical function in catatonic schizophrenia. This is strongly supported by a recent imaging study in these patients that demonstrated major deficits in functional activation in the medial ventral prefrontal cortex during emotional-motor stimulation (Northoff et al., 2004). Moreover, these findings demonstrated predominant disturbances in the right ventral prefrontal cortex. The findings are in full accordance with the observation that only patients with right/bilateral ventral prefrontal cortical lesions show deficits in the Gambling Task (Bechara et al., 2000; Manes et al., 2002). In contrast, this is not the case in those with lesions located exclusively on the left side.

In contrast, due to the absence of any deficits in the Gambling Task, one may infer intact function in the ventral prefrontal cortex in paranoid schizophrenia. This inference is supported by both neuropsychological and neuroanatomical evidence. Neuropsychologically, other tests requiring intact ventromedial cortical function also did not reveal abnormalities in paranoid schizophrenic patients (Abbruzzese et al., 1997). Neuroanatomically, imaging studies during working memory revealed no deficits in ventral prefrontal cortex in paranoid schizophrenic patients (Callicott et al., 2000; Manoach et al., 2000; Barch et al., 2001; Menon et al., 2001).

In contrast, there is strong evidence for dysfunction in dorsolateral prefrontal cortex (DLPFC) in paranoid schizophrenia. Neuropsychological deficits in the Wisconsin Card Sorting Test (WCST) (see also present results) lend strong support to DLPFC dysfunction (Abbruzzese et al., 1997). Imaging results also showed dysfunction in the DLPFC during working memory (Callicott et al., 2000; Manoach et al., 2000; Barch et al., 2001; Menon et al., 2001).

### *4.4. Conclusion*

Our results suggest a neuropsychological distinction between catatonic and paranoid schizophrenia with respect to decision-making and behavioral set shifting. Neuroanatomically, one may hypothesize that the deficit in decision-making in catatonic

schizophrenia is related to dysfunction in ventral prefrontal cortex. However, considering our sample's lack of other schizophrenic subtypes and of catatonic patients with other underlying diseases than schizophrenia, such an assumption may at best be regarded as exploratory. Furthermore, considering the small number of catatonic patients, the restriction to the post-acute state rather than to the acute one, and the exclusion of catatonic non-responders to lorazepam, this conclusion is quite preliminary.

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